SHAD FISHERY OF CHESAPEAKE BAY WITH SPECIAL EMPHASIS ON THE FISHERY OF VIRGINIA

RESEARCH REPORT 48

FISH AND WILDLIFE SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

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UNITED STATES
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ABSTRACT

A study of the American shad (*Alosa sapidissima*) in Chesapeake Bay was made in 1952. Catch and effort records were combined with data obtained from tagging studies conducted at the entrance to Chesapeake Bay, in the James and Potomac Rivers, and at Cove Point (Md.) to obtain population parameters for these areas. These studies were successful except for the results of the tagging at the mouth of the Bay, which data could not be used because of a disproportionate tag recovery-catch ratio between the various areas of Chesapeake Bay. Catch and effort records for previous years were available only for the Potomac River (1944–51). Total population and escapement were determined for each year in which these data were available. It is recommended that the States of Maryland and Virginia establish comparable systems for the collection of catch-and-effort records on the shad so that these basic data will be available for any future study of the Chesapeake Bay fisheries.

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SHAD FISHERY OF CHESAPEAKE BAY WITH SPECIAL EMPHASIS ON THE FISHERY OF VIRGINIA

The American shad, *Alosa sapissima* (Wilson), is an anadromous sh that spends most of its life in ıe sea, but must return to fresh- ater to spawn. The sexually ma- ıre adults enter their native rivers ı the spring and it is at this time ıat they are subject to the fishery. 'hose shad, which escape the fish- ry and spawn, are termed the spawning escapement." Those ıat survive after spawning return) the sea and are free to return and ɔawn the following year, provided ıey undergo no further mortality. 'he young fish spend the summer nd early fall in their native river nd then migrate to sea where they ɔmain until sexual maturity is at- ıined 3 to 6 years later.

The catch of shad along the tlantic coast has declined seriously nce the turn of the century. Be- ıuse of this decline the Atlantic tates Marine Fisheries Commis- on requested Congress to provide ınds to study the fishery. Legis- tion was passed authorizing funds ıd directing the Fish and Wildlife ɛrvice to make a study of the ɔastal shad fisheries to (1) deter- ine factors causing decline, (2) ɛtermine conditions favoring re- ɔvery, (3) provide basic informa- ɔn for scientific management so ıat each fishery may be managed to obtain an optimum sustained yield.

The Hudson, Connecticut, and Delaware River shad fisheries were studied in 1950 and 1951. During the spring of 1952 studies were concentrated on the shad fisheries of Chesapeake Bay and its tributaries. The Bay (fig. 1) is located in the States of Virginia and Maryland and is approximately 190 miles long. It varies in width from 12 to 24 miles in Virginia and from 3 to 16 miles in Maryland. Shad are caught in both the Bay proper and its tributaries. The tributaries producing the largest commercial catches of shad empty into the Bay along the western shore. From the southern to the northern end of the Bay they are as follows: (1) James River, (2) York River, (3) Rappahannock River, (4) Potomac River, and (5) Susquehanna River which empties into the head of the Bay. The shad producing area of the Susquehanna is small because Conowingo Dam, 10 miles above its mouth, completely blocks passage of fish to their historical spawning grounds. However, large catches of shad are taken on the Susquehanna Flats just below the mouth of the river.

The following shad streams on the eastern shore of Chesapeake Bay are listed from south to north:

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search Report 48.

Figure 1.—Map of Chesapeake Bay and tributaries divided into a number of arbitrary areas for the purpose of analysis.

(1) Pocomoke River, (2) Wicomico River, (3) Nanticoke River, (4) Choptank River, and (5) Chester River. Commercial quantities of shad are taken in these streams but in much smaller numbers than in the streams emptying into the west side of the Bay.

In the Bay, as in many other shad producing areas, the shad catch has decreased during the past 60 years (fig. 2, table 1). The catch reached a peak of 17,329,000 pounds in 1897 and then declined with some fluctuations to a low of about 3 million pounds between 1936 and 1941. Since that time it has become stabilized with minor fluctuations at a comparatively low level, averaging about 4.7 million pounds per year.

If fishing effort, fishing rate, catch, and size of run are obtained for one year then catch and effort records obtained in other years can be used in conjunction with the base year estimates to determine total population for each year records are available, provided (1) the efficiency of each type of gear remains constant, (2) the fishing effort is uniform throughout the season, and (3) the migratory pattern of the run is similar each year (Ricker 1940). If total population is known for a period of years then studies can proceed to determine what factors are affecting population size. If these factors can be determined and controlled then the fishery can be scientifically managed to obtain maximum yields.

The purpose of this study was to estimate fishing effort, fishing rate, catch, size of run, and spawning escapement for Chesapeake Bay and each of its major tributaries in 1952, and for every other year in which catch and effort data were available. Unfortunately, records for past years were available only for the Maryland fishery and the Potomac

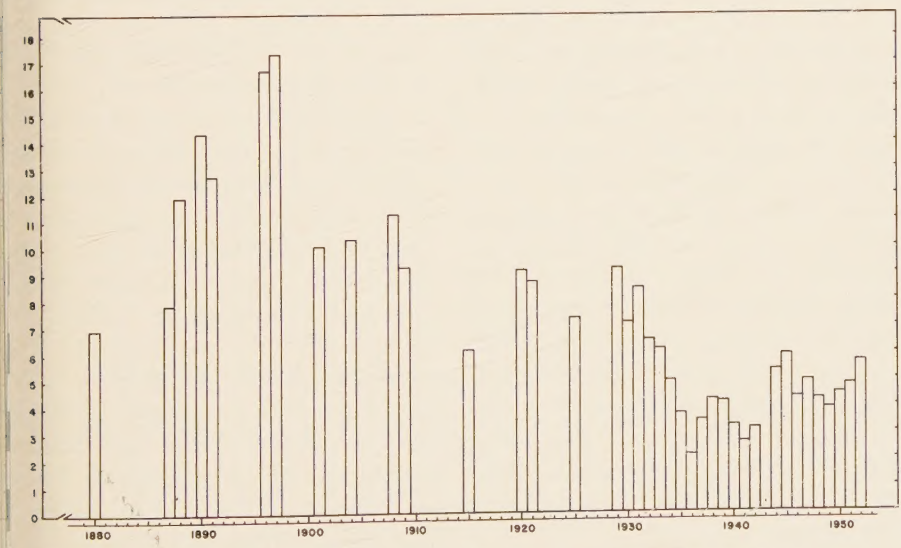

Figure 2.—Chesapeake Bay shad catch for some years 1880–1952 (U. S. Fish and Wildlife Service, 1953–55).

TABLE 1.—*Chesapeake Bay shad catch (in thousands of pounds) by Maryland an Virginia shad fishermen for some years 1880–1952 (U. S. Fish and Wildlife Servic 1953–55)*

Year	Maryland	Virginia	Total catch	Year	Maryland	Virginia	Total catch
1880	3,774	3,172	6,946	1933	1,374	4,817	6,1
1887	4,041	3,815	7,856	1934	885	4,105	4,9
1888	4,868	7,057	11,925	1935	800	2,883	3,6
1890	7,128	7,266	14,394	1936	570	1,615	2,1
1891	6,225	6,498	12,723	1937	405	3,086	3,4
1896	5,541	11,171	16,712	1938	600	3,607	4,2
1897	5,800	11,529	17,329	1939	624	3,559	4,1
1901	3,111	6,972	10,083	1940	446	2,811	3,2
1904	2,912	7,420	10,332	1941	534	2,126	2,6
1908	3,937	7,314	11,251	1942	725	2,430	3,1
1909	3,253	6,030	9,283	1944	711	4,665	5,3
1915	1,455	4,714	6,169	1945	617	5,299	5,9
1920	1,867	7,294	9,161	1946	719	3,599	4,3
1921	1,807	6,909	8,716	1947	868	4,086	4,9
1925	1,260	6,104	7,364	1948	1,004	3,206	4,2
1929	1,549	7,977	9,526	1949	1,083	2,801	3,8
1930	998	6,183	7,181	1950	1,443	3,031	4,4
1931	1,196	7,291	8,487	1951	1,554	3,294	4,8
1932	1,667	4,848	6,515	1952	1,636	4,007	5,6

River. The 1952 study was accomplished by obtaining complete catch and effort records from all areas of the Bay and tributaries and combining these data with those obtained from several tagging experiments which were conducted at the mouth of Chesapeake Bay, in the James River, in the Potomac River, and at Cove Point, Md.

The mouth of the Bay tagging experiment was conducted to determine population parameters of the entire Bay and tributaries. Tagging results in the James River, Potomac River, and at Cove Point, Md., were used to estimate population parameters in those areas and also to serve as a check on the results obtained from the mouth of the Bay tagging. Catch and effort records were obtained from Virginia shad fishermen by personal visits. Maryland shad catch and effort data were obtained from the Maryland Department of Research and Education.

This paper gives the results of th Chesapeake Bay investigation i 1952, with special emphasis on th Virginia shad fishery including tha of the Potomac River. The sha fishery of the Maryland portion c Chesapeake Bay was published as separate report (Walburg 1955).

We wish to express our apprec ation for the help and cooperation J. L. McHugh, Director, and th staff of the Virginia Fisheries Lab oratory, Gloucester Point, Va.; I V. Truitt, Director, and the staff the Maryland Department of R search and Education, Solomon Md.; and also of the many fishe men and fish dealers in the Ches peake Bay system. James Wha ton, statistical agent, U. S. Fish an Wildlife Service, supplied the Vi ginia Potomac River catch statisti for years 1944–51; Burton Lehma was in charge of the field studi conducted on the Potomac Rive and James Cating was in charge the mouth of the Bay studies.

RESULTS OF TAGGING SHAD NEAR CAPE HENRY (VA.)

The mouth of Chesapeake Bay is between Cape Charles and Cape Henry, Va., and is 13.8 miles wide. The only gear fished for shad in this area are the pound nets located just inside the Bay offshore from both Cape Henry and Cape Charles (fig.). The U. S. Fish and Wildlife Service (1953) lists 7,300 pounds of shad taken in Northampton County (includes Cape Charles) during the 1950 shad season and 33,400 pounds of shad taken in Princess Anne County (includes Cape Henry). Fishermen and fish dealers were interviewed in both the Cape Henry and Cape Charles areas to determine where a sufficient number of shad could be obtained for tagging. On the basis of these interviews and a study of catches for the previous years, it was decided that tagging would best be conducted in the Cape Henry area.

Tagging program

Shad were tagged from a pound net about one-half mile offshore from the Little Creek Naval Station at Norfolk, Va. A power boat was used to go from shore to the net, and a rubber life raft with a five car attached was used to hold fish taken from the pound net. All shad were tagged with Petersen disk tags which were attached to the back of the shad just below the dorsal fin. Scale samples were taken from each fish and it was sexed, weighed, and measured before being released. From March 18 through May 10, 1,395 shad were tagged of which 664 were males and 731 females (table 2).

Analysis of tag returns

To encourage the return of tags, fishermen in all sections of the Bay were visited frequently and a reward of 50 cents was paid for each tag recovered. To facilitate analysis of the catch and tag return data, Chesapeake Bay was divided arbitrarily into areas with rivers denoted by code letter "R" and areas in the Bay by code letter "B" (fig. 1).

The total number of tags returned from this experiment was 581 which represents 41.6 percent of the 1,395 shad tagged. Five hundred twenty-two of the 581 returns came from the shad fisheries of the Bay and tributaries, and 59 came from areas outside of the Bay. To separate the 59 recaptures (table 3) from outside the Bay from those which could be native to the Bay

TABLE 2.—*Number of shad tagged per week at Little Creek, Va.*

Fishing week (1952)	Tagging days	Males	Females	Total	Fishing week (1952)	Tagging days	Males	Females	Total
	No.	*No.*	*No.*	*No.*		*No.*	*No.*	*No.*	*No.*
Mar. 18–24	4	83	116	199	Apr 22–28	3	73	78	151
Mar. 25–31	4	78	122	200	Apr. 19–May 5	4	89	65	154
Apr. 1–7	4	105	105	210	May 6–12	4	66	69	135
Apr. 8–14	4	89	102	191					
Apr. 15–21	3	81	74	155	Total	30	664	731	1,395

and those which probably were not, criteria were established as follows: those recaptured within another shad river during the spawning season in that river were considered native to that river; those recaptured in the ocean or sounds other than Chesapeake Bay from North Carolina to Maine were considered of unknown origin; and those from the coastal waters of Canada after June 30 were also considered of unknown origin since Leim (1924) states that the spawning of shad in the Shubenacadie River is essentially complete by that time.

Four of the 59 were considered of unknown origin because they were caught in the ocean off New Jersey, Massachusetts, and Maine after June 15. They could have been shad that had spawned in Bay tributaries before migrating to the location of capture, or they could have left the Bay after being tagged to spawn elsewhere before migrating to the area in which they were recaptured. These four recaptures were not used in the analysis of outside Bay returns as it was not certain to which category they belonged.

Thirty-two of the remaining 55 tag returns were from the Hudson and Connecticut Rivers. Talbot [1] and Fredin [1] have established fishing rates of approximately 50 per cent for the Hudson and Connecticut Rivers in 1952. Assuming a similar fishing rate for all 55 out of the Bay returns, the estimated number of shad tagged that were not native to Chesapeake Bay is 110. This estimate is probably low because fishermen outside of the Bay were not visited for tag recoveries and therefore, some of the tags were probably not returned. By subtracting the number of tagged shad not native to the Bay from the total number tagged (1,395), it was estimated that 1,285 tagged shad were available to the Bay fishery. Five hundred twenty-two (40.6 percent), of these tags were returned from the Bay and its tributaries.

Estimates of the total run, fishing rate, and escapement for the entire Bay fishery could be made only if the tag recovery-catch ratio were similar for all areas of the Bay and its tributaries. The catch and number of tags returned by area were tabulated (table 4) and a chi-square test was made on these data. The chi-square value obtained (904.6) indicates a highly significant difference in the tag recovery-catch ratio between areas. The results of this test preclude any use of the tagging data to estimate total population, fishing rate, and escapement.

[1] Unpublished data, U. S. Fishery Laboratory, Beaufort, N. C.

TABLE 3.—*Shad tagged at Little Creek, Va., and recaptured outside Chesapeake Bay, 1952*

Location of capture	Number returns	Location of capture	Number returns
New Jersey	9	Massachusetts, Maine	
Hudson River	14	Canada	
Connecticut River	18	North Carolina	

TABLE 4.—*Total catch and tag return by area in the Chesapeake Bay system*

[See figure 1 for explanation of code]

Area code	Location	Total catch (no.)	Tag returns
	Cape Henry to James River	31,800	23
	James River	331,300	351
	James River to York River	52,500	14
	York River	400,000	40
	York River to Rappahannock River	104,000	8
	Rappahannock River	98,000	1
	Rappahannock River to Potomac River	53,000	3
	Potomac River	276,000	15
	Potomac River to head of Bay	482,000	67
Total		1,828,600	522

$X^2=904.6$, $P<0.001$.

There are three possible explanations why the tag recovery-catch ratio differed so greatly between areas. Some shad were caught February 14 at the tagging location but tagging did not begin until March 18. It is possible that the portion of the run, not sampled by tagging between these dates, was composed primarily of shad destined for Bay tributaries above the James River where the tag recovery-catch ratio was lowest. A second possibility is that there was a variation in the success of tag recovery from the different areas of the Bay. The third possibility, and probably the most important, is that the pound net from which fish for tagging were obtained was not adequately sampling all Bay populations.

Before any further attempt is made to estimate the Chesapeake Bay shad population by the tagging and recovery technique, a sampling method should be devised which will randomly sample all populations entering the Bay. Tagging should begin the first of February or when shad enter the Bay, and all fisheries in the Chesapeake Bay system should be visited to obtain tag returns and complete catch and effort records.

Migration of outside Bay recaptures

As shown earlier (table 3) 59 of the tag recoveries were made in areas other than Chesapeake Bay from North Carolina to Canada. Fifty-five of these are believed to be from populations foreign to the Bay. These recoveries give some evidence of the movement of shad in the Atlantic Ocean. Some shad from populations north of Chesapeake Bay, such as those from the Hudson River, Connecticut River, and Canadian rivers enter southern coastal waters in the spring, as some were caught and tagged here. After tagging they migrated north along the coast enroute to their native streams where they were recaptured.

This same movement pattern is indicated from shad tagging studies conducted on the Hudson River in 1950 and 1951 (Talbot 1954). The spring after tagging most of the tags were recovered in the Hudson River, but a few were returned from the coastal areas of North Carolina, Virginia, Maryland, Delaware, and

New Jersey. None of the tagged shad were recovered from the spawning grounds of any other river. These outside recaptures indicate that shad native to the Hudson River migrate at least as far south as the North Carolina coast.

North Carolina shad apparently entered the mouth of the Bay along with other groups of shad and after being tagged left the Bay to ente their native waters.

Twenty-two of the shad tagge at the mouth of the Bay were r captured in 1953. One was r turned from Winyah Bay, S. C., from the Neuse River in Nort Carolina, 13 from Chesapeake Ba and its tributaries, 4 from th Hudson River in New York, and from Canadian waters.

INVESTIGATION OF THE JAMES RIVER SHAD FISHERY

Description of river system

The James River has its source in the Allegheny Mountains and drains an area of 10,000 square miles. It is formed by the union of the Jackson and Cowpasture Rivers in Botetourt Co., Va., and flows in a southeasterly direction through Richmond and finally into Chesapeake Bay at Norfolk, a distance of 350 miles (fig. 3). The main tributaries of the James River are the North, Buffalo, Slate, Rivanna, Willis, Appomattox, and Chickahominy Rivers. Only the latter two tributaries support a shad run. The James River shad fishery includes both the James River and its two major tributaries, the Appomattox and the Chickahominy Rivers. In this report these rivers will be termed the James River system which is the southernmost river system entering Chesapeake Bay.

The Appomattox River originates in Appomattox Co., and flows a distance of 140 miles before emptying into the James River at Hopewell, 72 miles above Newport News. The Chickahominy River originat in Henrico Co., a few miles nort west of Richmond and flows a proximately 60 miles before empt ing into the James River 42 mil above its mouth.

History of the fishery

Prior to the construction Bosher Dam near Richmond 1851, large numbers of sh ascended to and were caught n the junction of the Jackson a Cowpasture Rivers some 350 mi above the mouth of the Jam (McDonald 1887). Since its co struction, the dam has prevent shad from going beyond Richmon thus limiting their migration approximately 105 miles of riv A dam was also built on the App mattox River in the mid-1800's Petersburg, but this did not se ously affect the shad run becau numerous falls and rapids upstre from the city blocked migrat before construction of the da Shad in the Chickahominy Ri formerly had access to 30 miles river, their upper limit being in

Figure 3.—Map of the James River system.

cinity of Providence Forge. Since)43, however, a low-head dam nstructed at Walker has limited e shad to the lower 17 miles of ver.

Methods of shad fishing in these ree rivers have changed little in e last half-century. In 1896 there re 87,000 linear yards of stake l net operated in the James tevenson 1899) compared to 51,000 ear yards in 1952. The upper and ver limits of the stake net fishery e still the same as they were in the ter part of the nineteenth cen- ry. The number of pound nets s changed considerably since 1896. that year only three pound nets hed in the river and they were ated off Newport News. Installation of this type of gear upstream from Newport News was prohibited at that time. In 1945, 26 pound nets fished the lower James.[2] This number increased from 37 in 1946, to 52 in 1947, and to 60 in 1948. After reaching this peak the number of nets decreased to 36 in 1951 and to 20 in 1952. In 1952, 14,000 linear yards of drift gill net were fished for shad in the James River system. The amount fished in former years is not known, but according to fishermen there has been little variation in the amount of this gear fished in recent years. Shad have always been taken incidentally by fyke nets and haul seines in the James River system.

[2] Unpublished data, U. S. Fishery Laboratory, Beaufort, N. C.

The total shad catch of the James River system is known for most years since 1896, but for some of these years, records of catches from individual tributaries are not available and are estimated (table 5). These estimates were determined from the total catch data of the three rivers for the years in which complete data were available. On the average, where separate figures were compiled, the shad catch in the James, Chickahominy, and Appomattox Rivers was respectively, 77, 20, and 3 percent of the total catch in the river system. These percentages were used to separate the catches where figures for the total river catches were available.

From table 5 and figure 4 it may be seen that the reported catch of 1,735,167 pounds of shad in 1896 was the largest ever recorded. From that year through 1931 the known catches remained at a fairly high level. In 1932 the catch dropped to 323,736 pounds and it continued low until 1944 when 904,300 pounds of shad were taken. From the data at hand it is impossible to determine the reasons for the decline in catches from 1932 through 1942, since the fishing effort expended make these catches is not know A catch of 904,300 pounds of sh in 1944 again placed the productio of the James River system back a par with that of earlier yea From 1944 through 1952 the catch have remained at a fairly high lev

Description of the 1952 shad fishery

The James River shad fishery c conveniently be divided into tw areas; the lower river fishery, whi is essentially an arm of the Bay, e tends from the river mouth u stream to the Chickahominy Riv and the upper river fishery whi extends upstream from the Chick hominy River to Hopewell inclu ing the two major tributaries, t Chickahominy and Appomatt Rivers. In the lower river fishe the fishing gear includes both pou nets and stake gill nets. A few fy nets and haul seines are fished h but the shad catch by these gear negligible. Pound nets are fish from the mouth of the river Menchville and stake gill nets fished from 2 miles below the Jam

Figure 4.—James River system shad catch for some years 1896 to 1952 (See table 5 for source of data).

TABLE 5.—*Catch of shad (in pounds) from the James River System for some years, 1896–1951* [1]

[Catches followed by an asterisk are estimated]

Year	James	Chickahominy	Appomattox	Total
1896	1,135,942	528,336	70,889	1,735,167
1901	838,766*	217,861*	32,680*	1,089,307
1904	715,963*	185,964*	27,895*	929,822
1909	584,134*	151,723*	22,759*	758,616
1915	554,725*	144,084*	21,613*	720,422
1920	754,722*	196,032*	29,404*	980,158
1921	639,426*	166,085*	24,912*	830,423
1929	791,880*	205,683*	30,853*	1,028,416
1930	1,134,055*	294,560*	44,184*	1,472,799
1931	651,928*	169,332*	25,400*	846,660
1932	251,401	70,463	1,872	323,736
1933	152,352	51,639	2,150	206,141
1934	296,100	64,000	3,800	363,900
1935	161,500	48,000	5,900	215,400
1936	85,300	27,400	2,705	115,405
1937	155,800	58,900	5,600	220,300
1938	153,200	67,500	1,800	222,500
1939	193,499*	50,260*	7,539*	251,298
1940	208,180*	54,073*	8,111*	270,364
1941	244,732*	63,567*	9,535*	317,834
1942	158,900	12,500	10,000	181,400
1944	763,500	109,200	31,600	904,300
1945	1,215,000	233,100	38,700	1,486,800
1946	548,000	270,800	57,900	876,700
1947	518,300	141,300	53,800	713,400
1948	518,300	93,100	16,900	628,300
1949	438,200	120,600	5,200	564,000
1950	439,500	137,300	25,800	602,600
1951	514,800	78,500	25,200	618,500
1952	918,984	69,579	5,400	993,963

[1] Data from published and unpublished reports of statistical surveys made by the U. S. Fish and Wildlife Service and its predecessors, the Bureau of Fisheries and the Commission of Fish and Fisheries. Catch statistics for 1952 compiled by the authors.

River Bridge to Claremont. The majority of shad caught in the lower fishery were taken by stake gill nets. Stake nets are set in rows and the individual stakes are placed approximately 30 feet apart. The length of net between the stakes is licensed as one net. The lengths of the rows and the number of nets in the rows vary considerably, dependent on the width of the river at the fishing location. The average size of the stake-net mesh is 5¼ inches, stretched measure.

In the upper section of the James River drift gill nets are fished exclusively with the exception of a few stake gill nets used in the vicinity of Claremont (these stake-net catches are included with those of the lower river fishery). The drift gill nets average about 150 yards in length and have a stretched mesh of 5¼ inches. In the Chickahominy River, shad fishing takes place from the river mouth to the dam at Walker which blocks further upstream movement. Drift gill nets are fished in this river and most fishing is in the Holdcroft area. Drift gill nets are also fished in the Appomattox River, but are confined to the lower 4 miles of river. Some fyke nets and haul seines are fished in the upper section, but as in the lower section, they are fished for other species and the catch of shad is negligible.

Shad fishing in the James River proper does not extend beyond Hopewell because the river above this point is narrow and tortuous, making net operation difficult. Massmann (1952) states that the primary spawning area for shad in the James River is below Hopewell,

and that no shad eggs were found in his survey more than one mile upstream from this location. Cable and Hollis [3] also found that the upstream limit of shad spawning in the James River was near Hopewell. This would seem to indicate that few shad venture beyond this point at the present time.

Catch statistics for 1952

To obtain catch-and-effort fishery records on this river all licensed commercial fishermen were interviewed and requested to keep a daily record of the number and type of nets fished and the number of fish caught. These data are summarized in table 6. The total catch in the lower river was 748,908 pounds which is 75 percent of the total catch for the entire system. The remaining 25 percent was made in the upper river fishery with the James River proper yielding 170,076 pounds and the Chickahominy and Appomattox Rivers producin 69,579 and 5,400 pounds, respec tively. The catch for 1952 in th James River was considerably mor than that of the average catch fro 1896 through 1950, whereas th Chickahominy and Appomatto catches were below average (tabl 5). The total catch in 1952 wa approximately 300,000 pounds mor than the average take since catche were recorded, beginning in 189

Fishing effort for pound nets wa determined by multiplying the num ber of pound nets fished by th average number of days fished b that gear. This gave fishing effo for pound nets in pound-net day Fishing effort for both stake an drift gill-nets was determined b multiplying the total length of gi nets fished in linear yards by th average number of days fished b each gear and dividing by 10 This gave fishing effort in hundre of linear yard days (table 6).

[3] Manuscript by Louella E. Cable and Edgar H. Hollis.

TABLE 6.—*Number of fishermen, number of nets, fishing effort, and total catch by type of shad net fished in the James River system, 1952*

[See text for explanation of fishing effort]

Fishery and gear	Number licensed fishermen	Number of nets	Fishing effort	Total catch (pound
Lower River Fishery:				
James River—				
Pound nets	4	20	1,160	12,
Stake gill nets	58	5,066	20,400	736,
Total				748,
Upper River Fishery:				
James River—				
Drift gill nets	46	68	2,750	170,
Chickahominy River				
Drift gill nets	35	57	920	69,
Appomattox River				
Drift gill nets	9	9	150	5,
Total				245
Grand total				993

agging study

The purpose of the tagging and ecovery program in the James iver was to estimate the size of the otal shad population and the proortion of shad escaping the fishery.

Shad were obtained from a pound et located immediately below the ames River Bridge on the Newport ews side of the channel. Tagging egan on March 1, and was conucted twice each week until April 5, when the run terminated. Shad ere tagged in proportion to the atch in the area of tagging. etersen disk tags were used and ey were affixed to the shad elow the dorsal fin. Fishermen ere visited at least once each week recover tags and to obtain catch cords. Tag recoveries began almost immediately after the first ay's tagging and continued until fter the tagging in the lower river ad been completed.

A total of 374 shad were tagged d 264 or 70.6 percent of these ere recovered. Nineteen tags were covered from areas other than the mes River system. Fourteen were covered from Chesapeake Bay d its tributaries above the James iver and 5 were recovered from e Hudson and Connecticut Rivs. The fishing rate in the Maryd portion of Chesapeake Bay as 52 percent (Walburg 1955). we assume that the fishing rate as also 52 percent in the Virginia aters of Chesapeake Bay and ibutaries exclusive of the James iver, then 27 tagged shad left the mes River for other areas of the esapeake Bay system. The fishg rate in the Hudson and Connecticut Rivers was approximately 50 percent;[4] therefore, approximately 10 shad tagged in the James left the river and subsequently became available to these northern river shad fisheries. Consequently, 37 tags were subtracted from the number applied in the James River and therefore 337 tagged shad were subject to capture by the James River fishery. Two hundred forty-five tagged shad were recovered in the James River system, hence the estimated fishing rate in 1952 was 73 percent.

In a study on the Umpqua River, Oreg., Gharrett (1950) found that Petersen disk tags caused tagged fish to be selective by becoming entangled in fishing gear. To determine whether or not selectivity occurred in the present study a chi-square test was made between the catch and tag recovery in each fishery as follows:

Item	Catch (in pounds)	Number of tags in catch
Lower fishery	748, 908	193
Upper fishery	245, 055	52
Total	993, 963	245

$$X^2=1.53 \quad P\sim 0.20$$

The chi-square of 1.53 with a probability of approximately 0.20 indicates that there was no significant difference in the proportion of tagged shad in the catch of the upper and lower areas of the river system. If tagged shad had been more easily captured than untagged shad a higher proportion of tags would have been taken in the lower river fishery than in the upper.

[4] Data obtained from other studies. U. S. Fishery Laboratory, Beaufort, N. C.

To determine the size of the 1952 James River shad run the following formula from Chapman (1948) was used:

$$N=\frac{nt}{s}$$

where N=population size; t=number of tagged shad (336); n=pounds of shad caught (993,963); s=number of tagged shad recovered (245). By solving the above equation N was found to equal 1,363,149 pounds.

To find the interval $(\underline{N},\overline{N})$ within which the true value of N fell with 95-percent confidence, equation (55) from Chapman (1948) was used:

$$(\underline{N},\overline{N})=\frac{nt}{s^2}\left[s+1.9208\pm\sqrt{(s+1.9208)^2-s^2\left(1+\frac{3.8416}{n}\right)}\right]$$

The confidence limits determined were:

$\overline{N}$=upper limit=1,544,862
$\underline{N}$=lower limit=1,202,793

Subtracting the total catch from the total population (1,363,149—993,963) the spawning escapement was estimated to be 369,186 pounds of shad or 27 percent of the total run.

Fredin (1954) by use of data obtained from a tagging and recovery program on the Connecticut River in 1951 was able to use catch and effort data of previous years to determine total population and spawning escapement for each year in which data were available. This was also done for the Hudson River shad fishery (Talbot 1954).

We were not able to determine total population and escapement for years prior to 1952 on the James River because, unfortunately, catch and effort data were not available. The data obtained from this study may be used to determine total populations and escapement in future years providing adequate catch-and-effort records are obtained. this is done changes in shad abundance can be followed and studies made to determine factors limiting abundance.

Age determination

Scale samples, fork lengths, and weights were collected from 4(shad during this study. Age was determined for 360 shad (144 male 216 female) using the method Cating (1953). These results are given in table 7.

TABLE 7.—*Age distribution by sex of shad from the James River, 1952*

Sex	Age	Number	Percent of total
Male	III	40	
	IV	72	
	V	28	
	VI	4	
Total		144	
Female	III	4	
	IV	146	
	V	46	
	VI	20	
Total		216	

The majority of males were 3 and 4 years old and the majority of females were 4 and 5 years of age.

The number of times each fish had spawned was also determined. Of the 360 shad for which age was determined 261 (73 percent) were spawning for the first time, 78 (22 percent) were spawning for the second time, and 19 (5 percent) were spawning for the third time. Two fourth time spawners were found.

INVESTIGATION OF THE POTOMAC RIVER SHAD FISHERY

Description of the river and fishery

The Potomac River is the largest tributary of Chesapeake Bay. It has its origin on the boundary between the States of West Virginia and Maryland and flows 290 miles in a southeasterly direction, before emptying into Chesapeake Bay. Below Washington, D. C., the Potomac is broad and sluggish, forming one of the largest estuaries on the Atlantic coast. This estuary is approximately 100 miles long and varies from 2 to 7 miles in width

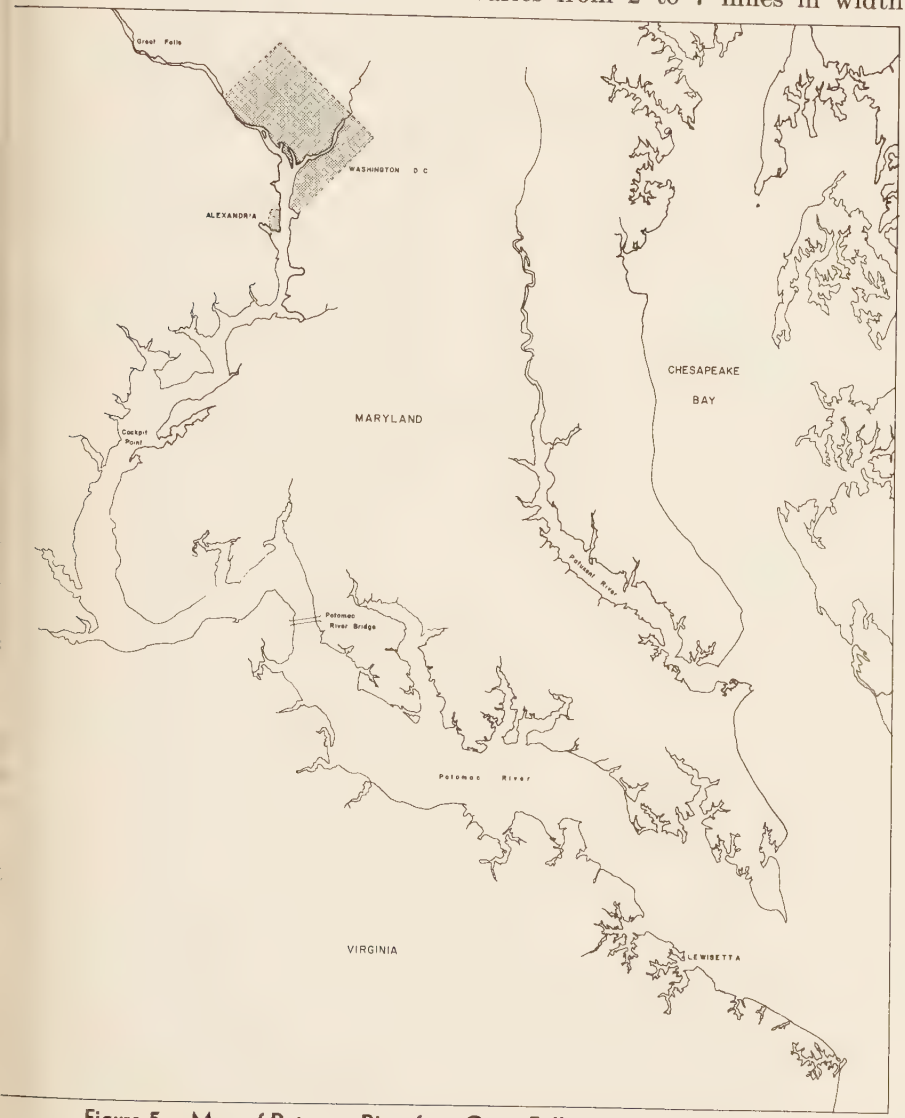

Figure 5.—Map of Potomac River from Great Falls to Chesapeake Bay.

(fig. 5). At Washington, the head of navigation, fluvial characteristics appear and between here and Great Falls, 15 miles above Washington, there are numerous shoals and several small falls. Prior to 1948, shad at times were able to ascend the Potomac to Great Falls; but since that time a dam at Little Falls, 10 miles below Great Falls, has blocked further upstream migration.

The shad fishery of the Potomac River can be separated into three areas based on the type of gear fished. Pound nets are fished from the mouth of the river to the Potomac River Bridge, a distance of 56 miles. From the Potomac River Bridge to Cockpit Point, a distance of 20 miles, stake gill nets are fished and from Cockpit Point to Alexandria, a distance of 24 miles, drift gill nets are fished.

History of the fishery

In colonial times the boundary between the States of Maryland and Virginia was set as the Potomac River. The boundary, for the most part, follows the extreme low-water mark on the Virginia side of the river. However, the right to fish the river is shared equally by citizens of both States. Potomac River shad catches have fluctuated widely through the years as shown graphically in figure 6. Since 1947, however, catches have been more uniform. Table 8 shows the shad catch by Maryland and Virginia fishermen in the Potomac River for most years 1896 to 1952. Over this period of years 83 percent of the shad caught in the Potomac River have been taken by Virginia fishermen and 17 percent by Maryland fishermen.

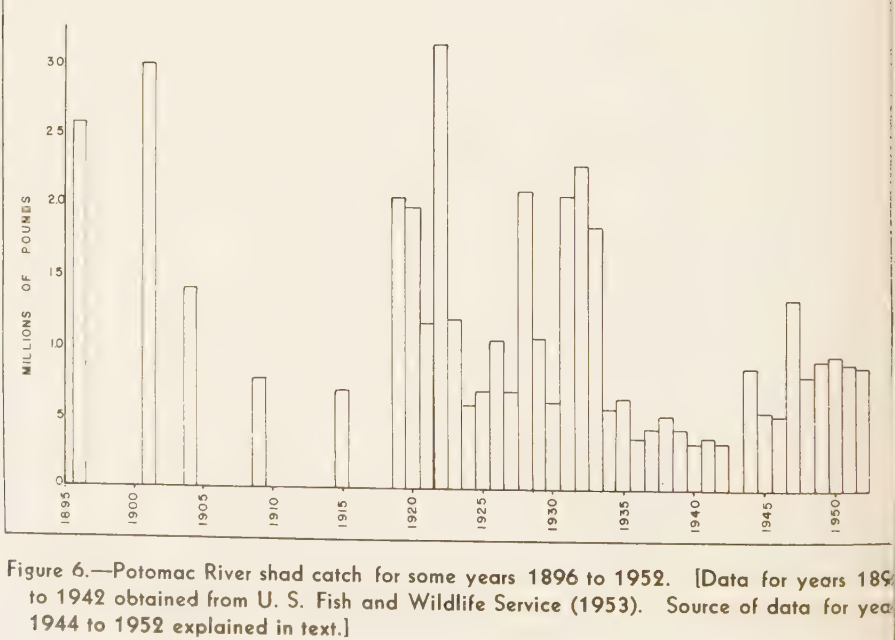

Figure 6.—Potomac River shad catch for some years 1896 to 1952. [Data for years 189 to 1942 obtained from U. S. Fish and Wildlife Service (1953). Source of data for yea 1944 to 1952 explained in text.]

TABLE 8.—*Potomac River shad catch in pounds by Maryland and Virginia shad fishermen for some years 1896 to 1952*

[Source of data 1896 to 1942, U. S. Fish and Wildlife Service (1953); 1944 to 1952, explained in text]

Year	Maryland	Virginia	Total catch	Year	Maryland	Virginia	Total catch
1896	874, 643	1, 690, 594	2, 565, 237	1933	175, 965	1, 661, 658	1, 837, 623
1901	547, 500	2, 431, 733	2, 979, 233	1934	35, 700	531, 400	567, 100
1904	311, 801	1, 085, 625	1, 397, 426	1935	82, 171	549, 000	631, 171
1909	116, 843	648, 049	764, 892	1936	48, 000	311, 800	359, 800
1915	64, 485	619, 523	684, 008	1937	43, 500	391, 400	434, 900
1919	354, 420	1, 687, 339	2, 041, 759	1938	51, 235	468, 400	519, 635
1920	302, 237	1, 677, 543	1, 979, 780	1939	44, 503	384, 000	428, 503
1921	138, 207	1, 022, 231	1, 160, 438	1940	75, 400	247, 400	322, 800
1922	706, 501	2, 409, 070	3, 115, 571	1941	38, 800	332, 500	371, 300
1923	308, 729	878, 653	1, 187, 382	1942	97, 575	230, 600	328, 175
1924	127, 285	450, 925	578, 210	1944	48, 065	802, 400	850, 465
1925	157, 786	538, 846	696, 632	1945	50, 318	495, 400	545, 718
1926	162, 861	871, 345	1, 034, 206	1946	62, 516	462, 200	524, 716
1927	103, 728	582, 853	686, 581	1947	98, 573	1, 237, 600	1, 336, 173
1928	383, 126	1, 694, 496	2, 077, 622	1948	108, 441	687, 700	796, 141
1929	225, 797	826, 487	1, 052, 284	1949	133, 210	770, 800	904, 010
1930	50, 345	550, 848	601, 193	1950	97, 714	833, 900	931, 614
1931	337, 518	1, 723, 518	2, 061, 036	1951	66, 518	810, 500	877, 018
1932	609. 258	1, 654, 910	2, 264, 168	1952	147, 391	705, 675	853, 066

Virginia shad fishermen who fish the Potomac River have always had unrestricted fishing. This was also true of the Maryland fishermen until 1941, when the Maryland Management Plan [5] was put into effect. With the enactment of this law license restrictions were imposed on all Maryland commercial fishermen, including those fishing the Potomac River. However, since Virginia fishermen had unrestricted licensing it was decided in 1945 that Maryland shad fishermen who fished the Potomac would also be granted unrestricted licensing, so that they could compete on an equitable basis with the Potomac River shad fishermen from Virginia.

Catch and effort statistics

Since no agency collects complete catch-and-effort statistics on the Potomac River shad fishery, it was necessary to obtain partial statistics from several sources. Maryland Potomac River shad statistics for years 1944 to 1952 were obtained from the Maryland Department of Research and Education. Maryland fishermen are required to submit weekly catch-and-effort statistics to this Department as part of the Maryland Management Plan. Statistics on shad catch and effort by Virginia shad fishermen who fished the Potomac River in 1952 were obtained from logbooks given to individual fishermen. Virginia statistics for the years 1944 to 1951 were obtained from the U. S. Fish and Wildlife Service. Table 9 shows the total catch by each type of gear fished in the Potomac River by Maryland and Virginia fishermen, 1944–52.

The Maryland catch records contained the total number of days fished, the amount of gear fished (gill-net length in linear yards), and the total catch made by each fisherman. The Virginia records contained the total amount of each type of gear fished (gill nets in square yards) and the total catch made by each type of gear. Because the statistics obtained from

[5] Law limiting the amount of commercial gear that can be fished in Maryland waters.

these two sources were tabulated differently, it was necessary to standardize and combine each State's fishing effort to obtain total effort expended by all types of gear fished in the Potomac River.

The total effort (net-days) by Maryland pound nets was determined each year by totaling the number of days fished by these nets (a pound net fished for 1 day equals one-net-day). The total effort of Virginia pound nets in 1952 was determined in the same manner. However, for years 1944–51 only the number of pound nets fished in Virginia waters was known. To obtain an estimate of the pound net effort for each year (1944–51) the average number of days fished by Virginia pound nets in 1952 (65) was multiplied by the number of nets fished each year (table 10). This is approximately the same number of days fished by Maryland pound-net operators during this same period.

Total effort of Maryland gill nets (stake and drift) was determined each year by multiplying the linear length of each net in yards by the number of days fished by that net and dividing by 100. The sum of the individual efforts gave fishing effort in gill-net-unit days (100 linear yards of gill net fished for 1 day was chosen as 1 net day). Total effort by Virginia gill nets (stake and drift) in 1952 was determined in the same manner. To determine Virginia gill net effort for years 1944–51 the amount of each type of gear fished in linear yards and the number of days fished each year had to be determined. Since the Virginia gill net data for years 1944–51 were in square yards it was necessary to estimate the average depth of Virginia gill nets so that the total linear yards fished each year could be determined. The study in 1952 revealed that the average depth of Virginia stake and drift gill nets was 4.44 and 7.00 yards, respectively. The number of days fished by gill nets each year was not known and therefore the average number of days fished by each type of gill net in 1952 was used. The average number of days fished by stake and drift gill nets was 60 and 45, respectively, for 1952. This is approximately the same average number of days fished by Maryland gill net operators during this same period. With the above

TABLE 9.—*Total shad catch (pounds) by type of gear in the Potomac River by Maryland and Virginia fishermen, 1944 to 1952*

Year	Maryland				Virginia				Total catch
	Pound net	Stake net	Drift net	Miscellaneous gear [1]	Pound net	Stake net	Drift net	Miscellaneous gear [1]	
1944	9,041	23,865	14,965	194	670,000	73,200	59,000	200	850,46
1945	8,359	28,817	12,554	588	294,200	83,000	91,000	27,200	545,71
1946	11,142	39,312	5,565	6,497	268,000	85,600	91,700	16,900	524,71
1947	22,697	57,571	14,688	3,617	992,900	113,400	108,800	22,500	1,336,17
1948	13,494	69,946	15,042	9,959	351,200	147,200	151,800	37,500	796,14
1949	27,055	90,756	14,635	764	356,400	150,100	228,200	36,100	904,01
1950	20,396	60,172	14,007	3,139	455,200	194,100	159,900	24,700	931,61
1951	5,658	40,261	19,640	959	424,000	218,500	139,200	28,800	877,01
1952	25,636	111,164	6,494	4,097	451,674	94,742	159,259		853,06

[1] Fyke net and haul seine catches.

TABLE 10.—*Total effort (net days) expended by each type of gear fished in the Potomac River, 1944 to 1952*

[See text for explanation of effort determination]

Year	Maryland effort			Virginia effort									Total effort		
				Pound net		Stake gill net			Drift gill net						
	Pound [1] net	Stake gill net	Drift gill net	Number	Effort	Length (square yards)	Length (linear yards)	Effort	Length (square yards)	Length (linear yards)	Effort	Pound net	Stake gill net	Drift gill net
1944	815	2,775	390	120	7,800	58,500	13,176	7,906	19,000	2,714	1,221	8,615	10,681	1,611
1945	1,893	3,514	621	208	13,520	146,800	33,063	19,838	42,300	6,043	2,719	15,413	23,352	3,340
1946	1,789	3,510	398	142	9,230	111,700	25,158	15,095	44,600	6,371	2,867	11,019	18,605	3,265
1947	1,393	4,606	622	154	10,010	55,500	12,500	7,500	50,000	7,143	3,214	11,403	12,106	3,836
1948	3,033	5,687	1,059	212	13,780	71,600	16,126	9,676	75,100	10,729	4,828	16,813	15,363	5,887
1949	3,603	5,070	534	295	19,175	89,900	20,248	12,149	90,400	12,914	5,811	22,778	17,219	6,345
1950	2,647	4,973	707	288	18,720	95,000	21,396	12,838	67,000	9,571	4,307	21,367	17,811	5,014
1951	1,507	4,329	818	189	12,285	62,800	14,144	8,486	60,500	8,643	3,889	13,792	12,815	4,707
1952	1,176	8,390	427	----------	14,477	----------	----------	5,075	----------	----------	2,333	15,653	13,465	2,760

[1] Includes haul seine and fyke net catch which was converted to pound net effort.

information we were able to convert the Virginia catch data and make it comparable to the Maryland data. Table 10 shows the total effort expended by each type of gear fished in the Potomac River from 1944–52.

Investigations on the Hudson and Connecticut Rivers (Talbot 1954; Fredin 1954) have shown that different types of gear which fish the same or different locations and catch different groups of shad are not equally efficient at catching shad. That is, a pound net or a drift gill net fishing for one day is not comparable to a stake gill net which fishes one day. Therefore, it is necessary to determine the fishing efficiency of each type of gear before the total effort of the various types of gear can be converted into standard fishing units.

In a fishery where the various types of gear are interspersed this can be done by comparing the catch-per-unit-effort values (Fredin 1954). However, this cannot be done for the Potomac River shad fishery because each type of gear fishes a specific area. That is, pound nets fish the lower portion of the river, stake gill nets fish the middle portion, and drift gill nets fish the upper portion. The pound nets fish the entire Potomac River shad population, the stake gill nets fish that portion of the population escaping the pound nets, and the drift gill nets fish the portion of the population escaping both the pound and stake gill net fisheries.

In the case before us, the efficiency of a given type of gear is measured by the proportion of available fish that it removes in a given period of time. We need to know the size of the population and the number of shad removed at a given location during the season before this proportion can be determined. To obtain the population estimate a tagging study was carried out in 1952 and catch and effort records were obtained from all commercial fishermen in all areas.

Tagging study

Shad for tagging were obtained from a pound net fished near Lewisetta, Va., which is approximately 10 miles inside the mouth of the Potomac River. Tagging was conducted once each week during the entire fishing season and an effort was made to tag in proportion to the shad catch in the area. Each shad was tagged with a Petersen disk tag which was affixed directly below the anterior insertion of the dorsal fin.

Three hundred twenty-one shad were tagged during the course of the experiment. Of these, 53 were recaptured in Chesapeake Bay, most of them (46) above the mouth of the Potomac River. A tagging experiment conducted in the Maryland part of the Bay in 195 indicated that the fishing rate in this area was 52 percent (Walburn 1955). If we assume that the remainder of the tagged shad that left the Potomac (7) were subject to a similar fishing rate, then 10 tagged shad left the Potomac River for other areas. Hence, 219 tagged shad remained in the Potomac River and were subject to capture. During the 1952 shad fishing season 853,066 pounds of shad were taken in the Potomac River by Maryland

nd Virginia fishermen. This catch ncluded 127 tagged shad, and there-ore the estimated fishing rate in he Potomac River was 127/219 or 8 percent. To determine whether he tagged fish were more liable to apture than the untagged a chi-quare test was made between the atch-and-tag-recovery data of each najor type of gear as follows:

Type of gear	Total catch (in pounds)	Number of tags recovered (by gear)
ound net	477,310	59
take net	205,906	38
rift net	165,753	30
Total	848,969	127

$$X^2=4.93 \qquad P \sim 0.10$$

he chi-square value obtained (4.93) as not significant, therefore, with 5 percent confidence we can say hat the gear used were not selective or Petersen tags in this experiment.

An estimate of the Potomac River had population can be made using he following formula:

$$N=\frac{nt}{s}$$

here N=population size, n=total atch (853,066 pounds), t=number f tagged shad available (219), and =number of tagged shad recap-ured (127). The estimated popu-tion size was found to be 1,471,035 ounds. Chapman's (1948) formu-a (55) was used to obtain 95 percent onfidence limits on this population stimate. Upper and lower popula-on estimates were 1,750,075 and ,236,493 pounds, respectively.

Conversion of fishing effort to standard fishing unit days

Now that population size and the catch by each type of gear are known the fishing efficiency of each type of gear can be determined. The fishing efficiency (p) is defined as that fraction of the available population removed by one unit of effort. One pound net fished for one day or 100 yards of gill net (drift or stake) fished for one day is termed one unit-of-effort. The fishing efficiency of each type of gear can be determined by using Fredin's (1954) formula $q^nN=E$. From which we derive

$$\log q=\frac{\log E/N}{n}$$

where $q=1-p$, E=escapement from a fishery, N=size of run available to a fishery, and n=number of units of effort by a particular fishery.

The pounds of fish available to the pound net fishery were 1,471,035 of which 477,310 were captured. Solving the above equation the q value obtained is 0.999975. Since $p=1-q$ the fishing efficiency of the pound net is 0.000025. The pounds of fish available to the stake net fishery was 993,725 of which 205,906 were captured. Solving the equation for this fishery q equals 0.999983 and therefore p equals 0.000017. The quantity of fish escaping both the pound and stake net fisheries and thereby available to the drift net fishery was 787,819 pounds. The gill nets caught 165,753 pounds of shad during the season. Solving the equation for

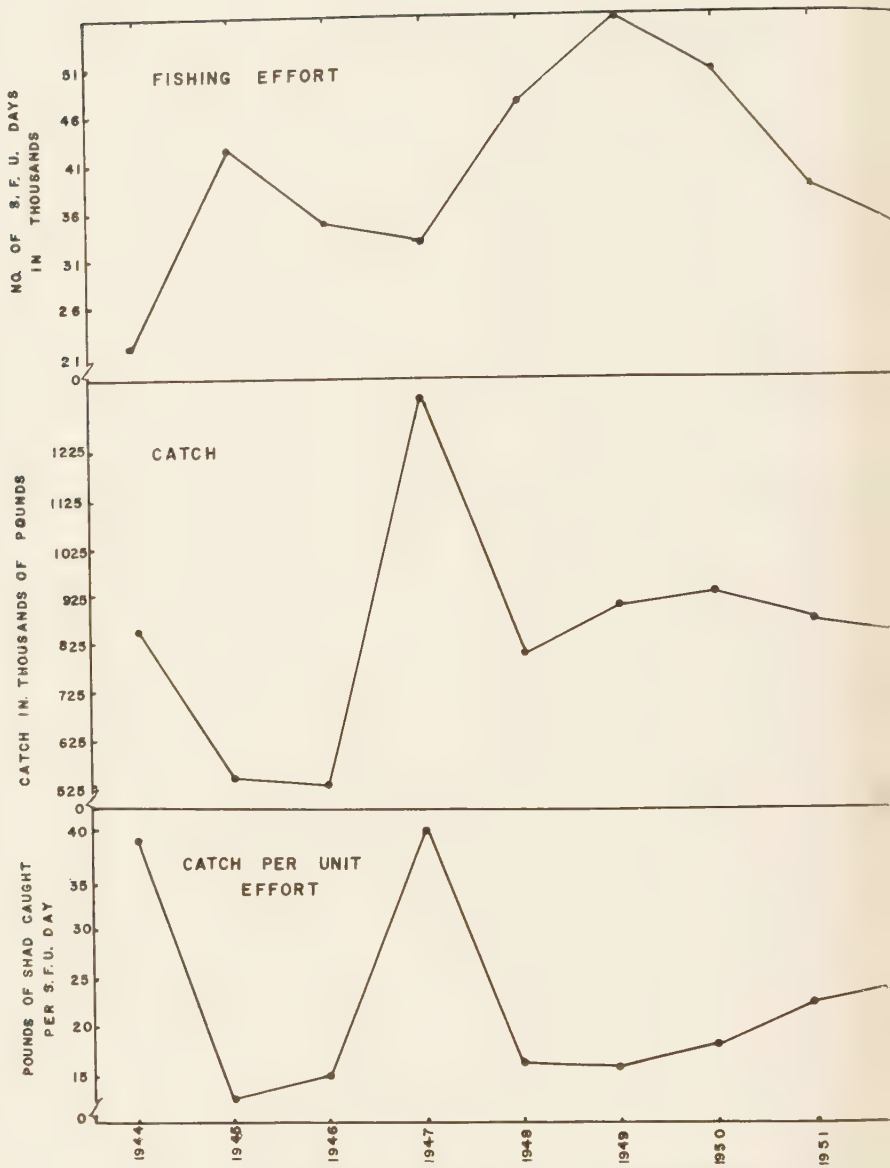

Figure 7.—Total effort, total catch, and catch per unit of effort of the Potomac River shad fishery, 1944–52.

this fishery the q value obtained equals 0.999914 and therefore p equals 0.000086. A comparison of the estimated fishing efficiencies of the various types of gear enables us to standardize all fishing effort in the manner of Talbot (1954). Compared to a pound net, stake and drift gill nets catch, resp tively, 68 and 344 percent as ma fish. The unit of effort is defi as a pound net fishing for one c which will be termed one standa fishing-unit day. Therefore stake gill net which fishes one is equivalent to 0.68 standard fi

TABLE 11.—*Total effort of Potomac River shad fishery, in standard-fishing-unit days by types of gear, 1944 to 1952*

[See text for conversion of effort to s. f. u. days]

Year	Effort, in standard-fishing-unit days, by—				Total catch	Catch per s. f. u. day
	Pound net and miscellaneous	Stake gill net	Drift gill net	Total		
					Pounds	*Pounds*
1944	8,615	7,263	5,542	21,420	850,465	39.70
1945	15,413	15,879	11,490	42,782	545,718	12.76
1946	11,019	12,651	11,232	34,902	524,716	15.03
1947	11,403	8,232	13,196	32,831	1,336,173	40.70
1948	16,813	10,447	20,251	47,511	796,141	16.76
1949	22,778	11,709	21,827	56,314	904,010	16.05
1950	21,367	12,111	17,248	50,726	931,614	18.37
1951	13,792	8,714	16,192	38,698	877,018	22.66
1952	15,653	9,156	9,494	34,303	853,066	24.87

ng units and a drift gill net which ishes one day is equivalent to 3.44 tandard fishing units. The total number of standard-fishing-unit lays per season is a measure of the otal fishing effort expended and is iven for years 1944 through 1952 n table 11 and figure 7 with the nnual total catch and catch per tandard-fishing-unit day.

Estimates of total population, 1944–52

Talbot (1954) gives a formula or estimating population size as ollows:

$$N=\frac{C}{1-q^n}$$

where C=catch, q=1−p, and n=ishing effort in s. f. u. days. Assuming p and q were constant from year to year and the fishing effort remained uniform throughout a given season we can use the above formula to determine the population size and escapement each year for which catch and effort data are available. The total run and escapement for each year 1944–52 are given in table 12.

It must be understood that the above estimates may be subject to error, being only as accurate as the catch-and-effort records from which they were obtained. They are given, however, as the best estimates obtainable from the available data.

Age determination

Scales from 800 Potomac River shad were studied to determine age.

TABLE 12.—*Estimated total effort, fishing rate, total catch, population size, and escapement of the Potomac River shad fishery, 1944–52*

Year	Total effort	Estimated fishing rate	Total catch	Estimated shad population	Estimated escapement
	S. f. u. days	*Percent*	*Pounds*	*Pounds*	*Pounds*
1944	21,420	41.9	850,465	2,029,749	1,179,284
1945	42,782	66.2	545,718	824,347	278,629
1946	34,902	58.7	524,716	893,894	369,178
1947	32,831	56.5	1,336,173	2,364,908	1,028,735
1948	47,511	70.0	796,141	1,137,344	341,203
1949	56,314	76.0	904,010	1,189,487	285,477
1950	50,726	72.3	931,614	1,288,539	356,925
1951	38,698	62.5	877,018	1,403,229	526,211
1952	34,303	58.0	853,066	1,471,035	617,969

Twenty-eight of these were discarded as unreadable leaving 772 (454 male and 318 female) for study (table 13). The majority of both males and females were 4 and 5 years old. A larger percentage of females, however, was 5 years of age or older.

The number of times each fish had spawned was also recorded. Of the 772 fish studied 641 (83 percent) were spawning for the first time, 119 (15 percent) for the second time, and 11 (1 percent) for the third time. Only one fish wa spawning for the fourth year.

TABLE 13.—*Age distribution by sex of 77 shad from the Potomac River, 1952*

Sex	Age	Number	Percen of tota
Male	III	37	
	IV	312	
	V	95	
	VI	9	
	VII	1	
Total		454	1
Female	IV	168	
	V	124	
	VI	26	
Total		318	1

DISCUSSION AND RECOMMENDATIONS

Before the cause of fluctuations in the size of Chesapeake Bay shad populations can be determined, basic data on the size of the shad population in each river must be available for a period of years. This can be determined through the collection of yearly catch-and-effort records and by conducting a well-planned tagging and recovery program. When these data become available all possible factors which could affect population size can be studied to determine their relation to population fluctuations.

This type study was conducted on the Hudson and Connecticut River shad fisheries (Talbot 1954; Fredin 1954) where catch-and-effort data of past years were available. On these two rivers it was found that more than 80 percent of the fluctuations in size of the run could be attributed to the number of fish that escaped the fishery and spawned. With this knowledge an the continued collection of yearl catch-and-effort data the size of th shad run in each river can now b predicted one year in advance wit a high degree of confidence. B controlling fishing effort it is po sible to manage these fisheries t obtain maximum yields.

Before the Chesapeake Bay sha fishery can be scientifically manage it is necessary that Virginia an Maryland establish a comparab system of collecting catch-and-effo statistics. After these records hav been obtained for a series of year studies can proceed to determine th factors affecting the size of the sha population in each river. Witho the collection of yearly catch-an effort records by both Marylan and Virginia, the scientific manag ment of individual shad populatio native to Chesapeake Bay is n possible.

SUMMARY

Chesapeake Bay shad production declined from 19 million pounds in 1897 to less than 3 million pounds in 1941. Since that time it has averaged about 4.7 million pounds per year. In an effort to determine the cause of the decline the Fish and Wildlife Service investigated the Chesapeake Bay shad fishery in 1952.

Catch-and-effort records were obtained for the entire fishery, also tagging and recovery programs were conducted at the mouth of the Bay, in the James River, in the Potomac River, and at Cove Point, Md. An analysis of the tag returns from the mouth of the Bay showed that there was a significant difference in the tag-recovery-catch ratio between areas, therefore, these data could not be used to estimate the total population and escapement for the Chesapeake Bay system. The study of the James River fishery indicated that in 1952 the catch was 993,963 pounds, the fishing rate 73 percent, and the size of run 1,363,149 pounds. The Potomac River study revealed that in 1952 the total catch was 853,066 pounds, the fishing rate 58 percent, and the size of run 1,471,035 pounds. Catch-and-effort records were available on this river from 1944 to 1952. With the data obtained from the study in 1952, the population size and escapement were determined for each year in which catch-and-effort data were available. The Cove Point tagging data were used in a study of the Maryland shad fishery which was published as a separate report.

Before the cause of fluctuations in Chesapeake Bay shad populations can be determined, the size of the population of shad in each river must be known for a period of years. When these data are available all factors that could affect the size of the population can be studied to determine their relation to the population fluctuations. Without the collection of yearly catch-and-effort statistics on a comparable basis by Maryland and Virginia the scientific management of individual populations native to Chesapeake Bay is impossible.

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